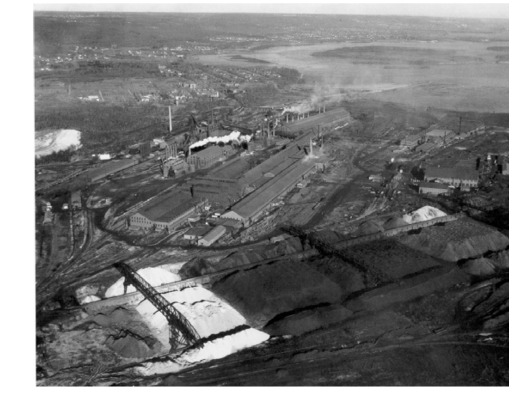
(Federal Water Pollution Control Administration, 1967)

Sediment Screening Values (SSVs): For screening evaluation of potential human health hazards



(1951; from Tweed Museum Exhibition, 1992)

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Currently there are no nationally accepted screening criteria or comparative values for evaluating human health hazards that may be associated with exposure to contaminated sediments. Standardized evaluation of chemical hazards from contaminated sediments is difficult because exposure potential varies greatly from site to site. The Minnesota Department of Health, with assistance from ATSDR, developed an integrated model to calculate Sediment Screening Values (SSVs) for evaluating underwater contaminated sediments. This model was applied at the US Steel, St. Louis River Site in Duluth, Minnesota.

SSVs are screening values. They are not cleanup numbers, or even goals. They are intended to help characterize contaminants of concern at a site, and to help identify the most important routes of exposure for specific chemicals. The screening calculations can be refined to account for site-specific data. Changes in the route of exposure contributions may be driven by data (e.g. PAH data from fish tissue), or by professional estimates (e.g. estimating the fraction of partitioning that may realistically occur). Examples are shown below.

Tables 1 and 2 show exposure data used for the US Steel St. Louis River Site sediment screening.

Table 3 contains the chemical properties for 4 chemical examples. The Biota-Sediment Accumulation Factor (BSAF) for mercury is specific for the St. Louis River Estuary.

Table 4 contains the results of the SSV model calculations, including a total SSV, as well as SSV_{route} for the 6 different potential routes of exposure.

Table 5 contains the results when different routes of exposure are adjusted or de-emphasized, or when modified parameters are used (mercury BSAF).

Table 6 shows the SSVs used to determine contaminants of concern at the US Steel Site.

Enter or modify exposure parameters:

Enter data	Spreadsheet calculated data

Table 1

Age (yr)	Wading Events (0.5 hr duration: ED_{wad})					
	May, September		June, July, August		Totals	
	8.6 weeks/year		12.9 weeks/year		EF_{wad}	EF_{wad-d}
	events/day	days/week	events/day	days/week	events/year	days/year
1 - 6	1	2	0	0	17.2	17.2
7 - 17	1	2	0	0	17.2	17.2
18 - 33	1	2	0	0	17.2	17.2
1 - 33	1.0	2.0	0	0	17.2	17.2

Age (yr)	Swimming Events (0.5 hr duration: ED_{swm})					
	May, September		June, July, August		Totals	
	8.6 weeks/year		12.9 weeks/year		EF_{swm}	EF_{swm-d}
	events/day	days/week	events/day	days/week	events/year	days/year
1 - 6	0	0	2	4	103	51.6
7 - 17	0	0	2	4	103	51.6
18 - 33	0	0	1	2	25.8	25.8
1 - 33	0	0	1.5	3.0	65.6	39.1

Table 2

			Chronic Exposures			Lifetime Exposure
Ages (years)			1 - 6	7 - 17	18 - 33	1 - 33
Averaging times	{ years }	AT	6	11	16	70
Body weight	{ kg }	BW	16.6*	45.2*	69.6*	62.9*
Body surface area	{ cm^2 }	SA_{ttl}	6,730*	13,500*	18,200*	
Inhalation rate	{ m^3/d }	InhRate	7.99*	15.0*	15.2*	13.7*
Ingested surfacewater, swimming	{ mL/hr }	$Ing_{SW(swm)}$	250†	250†	50	
Ingested surfacewater, wading	{ mL/hr }	$Ing_{SW(wad)}$	25†	25†	0.50†	
Suspended sediment concentration	{ mg/L }	SS_{SW}	370			
Ingested sediment, swimming	{ mg/hr }	$Ing_{Sed(swm)}$	92.5	92.5	18.5	
Ingested sediment, wading	{ mg/hr }	$Ing_{Sed(wad)}$	9.25	9.25	0.185	
Surface area exposed, swimming	{ % }	$SA_{\%swm}$	90			
Surface area exposed, wading	{ % }	$SA_{\%wad}$	20			
Fish meal frequency	{ meals/week }	MF			1.0	
Amount consumed	{ g/meal }	AC			210	
Skin adherence factor, swimming	{ mg/cm^2 }	AF_{swm}	0.2		0.07†	
Skin adherence factor, wading	{ mg/cm^2 }	AF_{wad}	1			

*** - Calculated from data in EPA Exposure Factors Handbooks**
† - Professional Judgement

Enter or modify Chemical data:

Table 3

Chemical	Metal =1 VOC = 2 Org = 3	MW	K_H	K_{oc}	Log K_{ow}	BSAF (BCF): mg/kg fish / mg/kg sed; mg/kg fish lipid / mg/L; mg/kg fish lipid / mg/kg organic carbon			ABS_{GI}	ABS_{Sed}	ABS_{Derm}	K_p	FA	ABS_{SW}	AF_{ED}	Reference Dose (RfD)	Reference Concentration (RfC)	Cancer Slope Factor (SF_c)	Cancer Unit Risk (UR_c)	Hazard Quotient (HQ) *
		g/mol	atm-m^3/mol	L/kg	Unitless	BSAF		BCF	Unitless	Unitless	Unitless	cm/hr	Unitless	(mg/(cm²·event)) / (mg/cm³) (calculated)	hr/event (calculated)	mg/(kg·d)	mg/m³	$(mg/(kg \cdot d))^{-1}$	$(\mu g/m^3)^{-1}$	Unitless
Benzo(a)pyrene equivalents	3	252	1.1E-06	1.20E+06	6.1	0.105	3		1	1	0.13	0.7	1	2.25	3.22			7.3	0.0011	
Mercury (MeHg and Hg^0 only)	1		1.1E-02			8.2	1		0.07	1		0.001		0.0005		0.0001	0.0003			0.73
Styrene	2	104	2.8E-03	910	2.94		2	1330	1	1		0.037	1	0.0458	1.24	0.2	1			
Arsenic	1	74.9					1		1	1	0.03	0.001		0.0005		0.0003	0.00003	1.5	0.004	

Incremental $Risk_c$	0.00001	Default HQ	0.2

SSV Model Outputs:

Table 4

Outputs - Calculated SSVs	Non-Cancer Endpoint							Cancer Endpoint						
	SSV_{ttl}	$SSV_{sed(ing)}$	$SSV_{sw(ing)}$	$SSV_{sed(derm)}$	$SSV_{sw(derm)}$	SSV_{inh}	SSV_{fish}	SSV_{ttl-C}	$SSV_{sed(ing)-c}$	$SSV_{sw(ing)-c}$	$SSV_{sed(derm)-c}$	$SSV_{sw(derm)-c}$	SSV_{inh-c}	SSV_{fish-c}
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Adj fraction or eliminate(*)														
Benzo(a)pyrene equivalents (B[a]P-PEQs)								0.0719	11.7	104	2.86	0.564	2,090	0.0856
									0.6%	0.1%	2.5%	12.8%	0.0%	84.1%
Adj fraction or eliminate(*)														
Mercury (MeHg and Hg^0 only) (HQ =0.73)	0.0206	91.3					0.0207							
		0.0%					100.0%							
Adj fraction or eliminate(*)														
Styrene	4.15	50,000	337		149	4.56	84.7							
		0.0083%	1.2%		2.8%	91.1%	4.9%							
Adj fraction or eliminate(*)														
Arsenic	49.0	75.1		141				29.3	57.1		60.4			
		65.3%		34.7%					51.4%		48.6%			

Modified SSV Model Outputs:

Table 5

Outputs - Calculated SSVs	Non-Cancer Endpoint							Cancer Endpoint						
	SSV_{ttl}	$SSV_{sed(ing)}$	$SSV_{sw(ing)}$	$SSV_{sed(derm)}$	$SSV_{sw(derm)}$	SSV_{inh}	SSV_{fish}	SSV_{ttl-C}	$SSV_{sed(ing)-c}$	$SSV_{sw(ing)-c}$	$SSV_{sed(derm)-c}$	$SSV_{sw(derm)-c}$	SSV_{inh-c}	SSV_{fish-c}
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Adj fraction or eliminate(*)										0.25		0.25		0.05
Benzo(a)pyrene equivalents (B[a]P-PEQs)								0.683	11.7	417	2.86	2.26	2,090	1.71
									5.8%	0.2%	23.8%	30.3%	0.0%	39.9%
Adj fraction or eliminate(*)														
Mercury - BSAF reduced to 1 - (MeHg and Hg^0 only) (HQ =0.73)	0.169	91.3					0.169							
		0.2%					99.8%							
Adj fraction or eliminate(*)			0.25		0.25	0.01	*							
Styrene	216	50,000	1,350		595	456								
		0.4310%	16.0%		36.2%	47.3%								

Table 6

Site-Specific Example: do not use

Site-Specific Sediment Screening Values
US Steel St. Louis River Site, Duluth, MN
(SSVs in gray - approaching or below background concentrations)

Chronic (non-cancer) Endpoint

		Sediment Screening Value	Route-of-exposure contribution (%)					
		SSV	Sediment Ingestion	Surfacewater Ingestion	Dermal Sediment	Dermal Surfacewater	Inhalation	Fish Consumption
Metals - Inorganics		mg/kg						
Arsenic	7440-38-2	49.0	65%	Not Evaluated	35%	Not Evaluated	Not Evaluated	Not Evaluated
Cadmium	7440-43-9	147	59%		41%			
Chromium III	16065-83-1	375,000	100%		Not Evaluated			
Chromium VI	18540-29-9	751	100%					
Copper	7440-50-8	9,260	100%					
Cyanide	57-12-5	5,000	100%					
Lead	7439-92-1							
Mercury (inorganic in sediment; methylmercury in fish) §	7439-97-6	0.0206	100%					
Methyl Mercury	22967-92-6		0%					100%
Nickel	various	5,000	100%					Not Evaluated
Zinc	7440-66-6	75,100	100%					
Volatile organic compounds (VOCs)								
Benzene	71-43-2	0.00491	0%	1%	Not Evaluated	1%	97%	1%
Ethylbenzene	100-41-4	0.341	0%	1%		3%	92%	5%
Styrene	100-42-5	4.15	0%	1%		3%	91%	5%
Toluene	108-88-3	0.120	0%	1%		2%	94%	3%
Xylenes (mixed)	1330-20-7	0.0783	0%	0%		0%	100%	0%
Polycyclic Aromatic Hydrocarbons (PAHs)								
Acenaphthene	83-32-9	21.9	0%	4%	0%	40%	23%	33%
Acenaphthylene (toxicity surrogate - acenaphthene)	208-96-8	20.9	0%	5%	0%	40%	23%	31%
Anthracene	120-12-7	689	1%	5%	2%	61%	12%	19%
Benzo(a)pyrene (or B[a]P equivalents)	50-32-8	Non-Cancer Endpoint Not Evaluated						
Fluoranthene	206-44-0	83.4	1%	2%	2%	58%	1%	35%
Fluorene	86-73-7	49.5	0%	8%	1%	56%	18%	17%
Methylnaphthalene (toxicity surrogate - naphthalene)	1321-94-4	0.478	0%	0%	0%	1%	97%	2%
Naphthalene	91-20-3	0.103	0%	0%	0%	1%	99%	0%
Perylene (toxicity surrogate - pyrene)	198-55-0	55.9	1%	0%	2%	66%	0%	32%
Phenanthrene (toxicity surrogate - anthracene)	85-01-8	741	1%	4%	2%	56%	4%	33%
Pyrene	129-00-0	79.5	1%	2%	2%	49%	1%	45%
Dibenzo-p-dioxins/dibenzofurans								
2,3,7,8-TCDD (or 2,3,7,8-TCDD equivalents)	1746-01-6	1.41E-06	0%	0%	0%	0%	0%	99%
Other Organics								
Carbazole	86-74-8	Non-Cancer Endpoint Not Evaluated						
Dibenzofuran (unsubstituted)	132-64-9	1.77	0%	3%	0%	22%	3%	72%
Hexachlorobenzene	118-74-1	0.888	0%	1%	1%	17%	63%	18%
Octachlorostyrene	29082-74-4	0.0188	0%	0%	0%	0%	0%	99%
PCBs (Polychlorinated Biphenyls)	1336-36-3	0.00460	0%	0%	0%	2%	1%	97%

Cancer Endpoint

Carcinogens		Cancer Sediment Screening Criteria	Sediment Ingestion	Surfacewater Ingestion	Dermal Sediment	Dermal Surfacewater	Inhalation	Fish Consumption
Arsenic	7440-38-2	29.3	51%	Not Evaluated	49%	Not Evaluated		
Benzene	71-43-2	0.00325	0%	0%	Not Evaluated	1%	98%	1%
Benzo(a)pyrene Equivalents	50-32-8	0.0719	1%	0%	3%	13%	0%	84%
2,3,7,8-TCDD (or 2,3,7,8-TCDD equivalents)	1746-01-6	4.7E-08	0%	0%	0%	0%	0%	100%
Carbazole	86-74-8	2.85	0%	3%	0%	10%	0%	87%
Hexachlorobenzene	118-74-1	0.156	0%	0%	1%	19%	42%	38%
PCBs (Polychlorinated Biphenyls)	1336-36-3	Cancer Endpoint Evaluated as part of 2,3,7,8-TCDD TEQ						

Discussion: The results, shown in **Table 4,** suggest that the largest exposure to Benzo[a]pyrene Potency Equivalence (B[a]P PEQ) comes from fish ingestion. PAH accumulation in fish is always an issue; with most empirical data suggesting little accumulation, but some studies showing differential accumulation dependent on compound and fish species. Therefore, at some locations it may be appropriate to adjust the route-specific SSV for B[a]P PEQ. Calculations of the equilibrium partitioning of carcinogenic PAHs (cPAHs) into surface water are also likely to be overestimated. Either data can be acquired, or estimates of the effectiveness of partitioning into surface water (e.g. above agitated sediments) can be made. **Table 5** shows the effect on the SSV of changing the effectiveness of the fish consumption pathway to 5% and partitioning of cPAHs into surfacewater to 25% of the calculated maximums. Note the change in percent contribution by route.

The mercury BSAF (methyl mercury:inorganic mercury) was calculated to be 8.2 (kg_{sed} / kg_{fish}) for the entire St. Louis River estuary for a 20 inch walleye. At other locations the BSAF for mercury may be different. For **Table 5**, the BSAF of mercury was reduced to 1.

Initial SSV calculations suggest that most exposure to styrene (and other VOCs) in sediments will come from inhalation. Chemicals in sediments will need to partition through water into air to be inhaled. Calculations using equilibrium partitioning will likely result in substantial over-estimation of this potential exposure route. Therefore, adjustments should be made using surface water concentration data or air data. **Table 5**, shows the change to the styrene SSV that occurs when partitioning is 1% of the calculated maximum. In addition, it is unlikely that there will be any significant accumulation of styrene in fish, so that potential route of exposure is eliminated. Furthermore, partitioning from sediments into water is limited so that affected routes only contribute ¼ of their calculated maximum. Note that these changes lead to an increase in the SSV from 4 to 200 mg/kg.

The SSVs in **Table 6** were used to evaluate contaminants at the US Steel Site. Note that the calculated SSVs for mercury, 2,3,7,8-TCDD TEQs, and PCBs may approach, or are below, background concentrations. For these chemicals, screening should be related to background concentrations, not the SSVs.

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